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THE "BAD LANDS" OF WYOMING AND THEIR FOSSIL REMAINS.

BY

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Macaulay has observed that the dexterous Capuchins never choose to preach on the life and miracles of a saint till they have awakened the devotional feelings of their auditors by exhibiting some relic of him—a thread of his garment, a lock of his hair, a drop of his blood. On the same principle, I would gladly prepare what I have to say this evening with an exhibition of some relic of the departed, for I, too, like the Capuchins, am to speak of a race of beings long since passed away. But I have no relic, no lock of hair, no drop of blood, not even a fragment of bone, to show in hope of awakening your interest and so securing a patient hearing.

Bones, indeed, are not wanting; yet the absence of them on this particular occasion is scarcely to be deplored, as there are few things which at first sight seem so ill-fitted to awaken interest as an old fossil. I am sure that to nine-tenths of the people who wander among the cases of a geological museum, a femur from the tertiary, or half a dozen vertebræ from the cretaceous, are just about as interesting as boomerangs from Australia or a carved idol from Japan. They are simply curiosities, something to be talked about for a few minutes and then forgotten, and of no earthly use whatever, unless it be as pretexts for a number of very learned gentlemen to meet once every year at some fashionable watering-place, to enjoy the festivities and read long papers on geology. But in truth they have always been more interesting than we are apt to think; and when the history of civilization comes to be written, as it is to be hoped some day it will be, the strangest chapter of all will be the narrative of the influence which fossil bones have exerted over the human mind at every stage of the long march from ignorance and barbarism to the highest degree of knowledge and refinement. That influence is distinctly traceable in the myths, in the legends, in the folk-lore, in the superstitions of every race of men of whom we possess any accurate information whatever. Nay, more, the grotesque monsters that figure so prominently in heraldry, and who, as they sit guard over lovely princesses and great stores of gold and jewels, are constantly being combated by the heroes of nursery tales, owe their existence to the finding of a few old bones, ages ago, by an ignorant people.

Honest Herodotus, whose wildest stories are every day being more and more fully verified, furnishes us with an illustration of this, quite to the point, in his account of the griffin. He assures us that griffins were common in Scythia, that they possessed the gold mines there, and that the Aramaspians fought with them, slew them, and took away the gold, and that if any one were so incredulous as to doubt this, the Scythians could show him the bones of the griffins they had killed. For a long time this story was thought to be quite on a par with that of the lake-dwellers, and another instance of the exceeding gullibility of the "Father of History." But a geological survey of the region where the Aramaspians lived was made a few years since, and then the truth came out fast. There, sure enough, were the gold bearing strata, and just above them a layer rich in bones of enormous animals that became extinct long before the human race began to exist. These bones the Scythians found in their search for gold. They seemed to be the remains of animals that had once watched and brooded over the gold, and from this the Aramaspians made their story of the griffin, and used it to terrify their neighbors and keep them from disturbing the mines.

Nor is this by any means an isolated instance. In Siberia precisely the same thing occurred, and there gave rise to the story of a great bird, as conclusive evidence of the existence of which a quantity of ivory claws some three and some four feet long are shown. But the claws so triumphantly exhibited are, in reality, the tusks of a creature whose official title is *Rhinoceros tichorlimus,* an animal of great size, which, in pre-glacial days, wandered over Europe from one end to the other. Indeed, the tusks of this beast always have been, and still are, dug up on the continent. In the middle ages they were regarded as the claws of the griffin. Sometimes drinking-horns were made of them, and sometimes, mounted in gold and silver setting, they were preserved in churches and libraries as relics of great price. Gerard Leigh, a famous herald of Elizabeth's day, had one of them, and says of griffins: " I think they are of great hugeness, for I have a claw of one of their paws which should show them to be as big as two lions." Mary of Hungary had another; a third was long preserved in Catton's Library; a fourth was in the collection of the Royal Society; and down to a very few years ago one might have been seen in Corpus Christi College, at Oxford, so mounted on little gilt claws as to leave no doubt as to what it was thought to be.

While from the tusks of the rhinoceros were thus made griffins, from the bones of mastodons and elephants were made giants. The writings of early naturalists and historians are full of instances of the discovery of giant remains. Boccaccio makes mention of the bones of a giant dug up near Trapani, in Sicily. The moment they were exposed to the air they crumbled into dust, but happily, he says, three-tenths were preserved, which weighed an hundred ounces, and were so large that a hundred teeth of ordinary mortals could easily have been made of them. These tusks, which were those of an elephant, the men of Drapani long preserved in their church. They were agreed that the former possessor must have been a man at least 200 cubits high, but they could not agree as to his name. Some said he was Eric, and some Etbellus, and others a Cyclops, even that particular Cyclops into whose single eye Ulysses thrust the scorched mast. The skull and shoulder blade, six cubits broad, of Briatus, was dug up in 1456. Fifty years later, while some workmen were digging in the trenches at Roeven, they came upon the remains of a giant whose skull held a bushel of corn and whose shin bones reached to the girdle of the tallest man among them. But before this a most memorable heap of bones was found at Reyden, and celebrated in song by Felix Plater, the renowned physician of Basle. The bones, reputed there to belong to a giant 16 feet high, have long since been consigned to a remote department of zoology. But such is the tenacity of human credulity that the giant still holds his place in the popular belief and his standing-ground beside the arms of Lucerne, and he is likely to hold them for many a day yet to come.

At the time of the conquest of Mexico, Bernal Diaz was told by the natives of the great size and deeds of the giant that once dwelt in the country. The stories were too absurd for even so credulous an historian as Diaz to believe, till, in proof of them, the natives brought him the leg bone of one of them. This he measured against himself and found it to be as tall as he, and he was, he assures us, a man of reasonable height. But there are instances of later date. In 1712, we find Dr. Mather presenting the Royal Society with a very learned paper on the bones of a giant dug up at Claverack, on the Hudson. It is needless to say they were the bones of a mastodon. And to-day, over the whole area of the Pampas, which is indeed a vast sepulchre of extinct animal remains, the names "Hill of the Giants," "Field of the Giants," are, travelers tell us, an unerring guide to the geologist in his search for bones.

It is not worth while to follow this further. Enough has been said, I am sure, to illustrate at least one of many ways in which fossil bones have influenced human thought. Yet there is one other opinion resulting from all this which must not be passed by in silence. From the belief that "there were giants in those days," to the belief that all men were in early times taller than they now are, there is but one step, and that is soon taken. No man in his senses now thinks that there ever was such a thing as a man twenty feet high. The mere statement of such a thing would raise a jeer in any well regulated nursery. But there are very many men who sincerely believe that our race has sadly degenerated; that at some time, now far in the past, men were stronger, bolder, of a more lofty size; that the Gauls and Britons Cæsar conquered were taller by a hand's breadth than the present inhabitants of Paris and London; that the Praetorians of Augusta were of greater height than the Grenadiers of Frederick. Much has been said in behalf of this idle theory, which was never so fully stated as by Henrion. The huge bones so often brought to light had sorely puzzled him. He could not bring himself to accept an occasional giant. He affirmed that since the day of creation the human race had steadily degenerated in size, so steadily, indeed, that he made out a table of the height of the great men of antiquity. Adam, said he, was 123 feet high, Eve 118, Noah 98, Abraham 28, Moses 13, Hercules 10, Alexander 6, Cæsar 5, and had not God in his infinite mercy there staid the decline, men would in his time 1718 have degenerated into atoms. It seems scarcely credible that such are the deliberate statements of a French Academician.

The day, however, for such reasoning has gone by. The labors of comparative anatomists have made it impossible for the veriest schoolboy to mistake, as Buffon did, the bones of an elephant for those of a man. The fossil remains which troubled the men of our earlier time—the skulls holding a bushel of corn, the teeth from which an hundred human teeth could easily have been made, the shin-bones reaching up to the girdle of the tallest man among them—have all been discovered to be quite unlike the bones of man. There is no longer any doubt that they are the remains of animals, and with them have been constructed creatures whose names are not to be found in any of the writings of Cuvier, of Buffon, of Audibon. To such an extent has this been carried, that when to the labors of the anatomist are added the labors of botanist and geologist, sufficient material is at hand for a fair description of the physical geography of the earth in past ages. Not only is it possible to mark down on the map with much accuracy the margins of seas and lakes dried up nobody knows how long ago, but it is also possible to speak with absolute certainty of the reptiles that swarmed in those waters, of the plants and trees that covered the land, of the animals that wandered among the hills and forests.

Now, it seems to me that this is a branch of geography not to be despised. It seems to me that it is quite as interesting and almost as useful to know something of the physical features of the earth, and of the geographical distribution of plants and animals, in times past as in times present, and that our stock of knowledge is just as likely to be increased by a study of the rocks as by the discovery of the north polar sea or the exploration of the heart of Africa. Commerce will not be extended, trade will not be improved, wealth will not be increased one penny by the discovery of the northwest passage, or by the announcement of the fact that in the heart of Africa are mountains and rivers and great seas. Yet this is no reason whatever why those regions should not be explored, nor does it take away one jot from our admiration of the courage, the patient endurance, the indomitable will of the little band of men to whom we owe every bit of information we possess concerning those spots. Precisely the same thing is true of the geography of the past world. It will not add to our prosperity as a nation to know that the great plains of the West, where are now some of our richest States, were once the bed of a sea, and that when the waters had gone down the dry land was covered with a flora and inhabited by a fauna every trace of which is buried up under a thousand feet of rock. Yet that is no reason why the fact should not be ascertained with the utmost fullness of detail.

Thinking this way, I would ask your indulgence for a few minutes this evening while I depart from the usage of the Society, and speak of the geography of a part of a past world. I shall endeavor to set before you a picture of our West in that age to which geologists have given the name cretaceous. I shall attempt to give some account of the physical features of the country and of its climate, and to describe, as best I may, the plants and trees which grew upon the land, and the reptiles and mammals which inhabited the seas and forests, long before the mountains of California were thrown up, before the Gulf States had arisen from the sea, and while the green marl beds of New Jersey and the white cliffs of Dover were still in the process of making.

Such a description, composed from the scanty materials of a geological cabinet, fossil bones and skulls, fossil leaves and fishes, rock-sections and notes taken in the field, must of necessity be very imperfect. Yet it will not have been made in vain if it affords even an imperfect idea of a world that passed away nobody knows how many thousands of years ago, and whose plants and animals are now found buried up under a thousand feet of rock. Wyoming has been selected from among all the territories because of its exceeding richness in fossil remains, and because much of the evidence to be presented has been there collected by two expeditions sent out under the auspices of the geological museum at Princeton.

But it may not be amiss to preface our description of the ancient geography of that territory with a brief sketch of its present geographical features, and of the evidence, and the manner of collecting the evidence, on which our account of its ancient geography is based.

Wyoming lies almost midway between the valley of the Mississippi and the Pacific, on that great plateau from whose surface rise the innumerable ridges and foot-hills which, taken together, make up the Rocky mountains. The plateau, often called the "Great American desert," is, to the eye, as level as the floor, but in reality has a steady upward slope from the Mississippi to the Rockies. An idea of this gradual slope may be had from the profile of the Union Pacific Railroad. At Chicago the elevation above the sea is some 600 feet. At Omaha, 494 miles west, the elevation is 966 feet. At Cheyenne, 1,010 miles from Chicago, the plateau has risen to 6,041 feet. From Cheyenne the ascent is more rapid, till at Sherman, 33 miles west of Cheyenne, it reaches 8,242 feet. Thence the slope is steadily downwards to the Pacific. Wyoming lies on each of these slopes, with a mean elevation of 7,000 feet above the sea. In the extreme northwest corner is the Yellowstone National Park. To the south, and extending to the middle of the territory, is a succession of mountain ridges and high plateaus. Beyond these spread out the great plains, connecting with those of the Missouri on the east, and forming a pass more than 140 miles wide over the Rocky mountains.

During the cretaceous age, these plains lay at the bottom of a great sea. The waters of innumerable rivers, flowing over the land, eroding and wearing away the rocks and earth, fed the sea and brought to its shores great quantities of detritus. This the currents took up, and, conveying it far from the shore, deposited it in those vast beds of sand, of gravel and of mud which now make the rocks and soil of the plains.

So distinctly are the cretaceous rocks marked off from those of an earlier and a later time, that the boundaries of the sea on whose bed they were deposited have been almost as accurately defined as the boundaries of many of the territories it once covered. The shoreline on the east extended from about the middle of Arkansas northwestward to near Fort Riley on the Kansas river, ran thence to

Omaha and, sweeping off to the northeast, passed into the British possessions not far from the head of Lake Superior. To the west the extent of the sea was vast, but the western shore is probably now buried under the waters of the North Pacific ocean. But, as time went on, this sea-bottom was slowly elevated, the water grew shallower and shallower, the surface grew more and more contracted, till at last the sea was completely enclosed on the west and opened into the Pacific and Atlantic at the Gulf of Mexico and the Arctic sea. The gradual elevation of the land continuing, the area of the water grew smaller and smaller, and as ridge after ridge of the sea-bottom came to the surface, low bars were formed, which cut off large areas and turned them into fresh water lakes. The whole region once submerged by the cretaceous sea was thus, at the close of that age, spotted with innumerable lakes and ponds.

One such fresh water lake covered the whole southern plateau of Wyoming from the Mintah mountains in Utah on the south to the Wahsatch mountains on the west, and the Wind river mountains on the east. Its waters teemed with life; along its shores grew a rich tropical vegetation, which furnished food to animals as numerous and varied as those of any other fauna, recent or extinct, in any part of the world. But all this was doomed to destruction. The land continued to rise, and the great Mintah lake was emptied, apparently in successive portions and after long intervals, till finally it was drained to the very bottom. What had for so many ages been the bed, first of a great salt sea, and then of a fresh water lake, became the dry land, and the ancient lake deposits now form the surface of the country and appear as an extensive plain.

Unlike the sedimentary deposits at other places and of other times, those of Wyoming have never been pressed into hard rocks beneath piles of later sediment. They have not been roasted and crystallized by internal heat. They yield readily to the action of water, which has eroded them on a most extensive scale. Indeed, there is scarcely an inch of territory which is not now far below its ancient level. From the surface of the plains rise in every direction, sometimes isolated, sometimes in groups, sometimes in long lines like an immense earthwork, flat-topped hills and tablelands, which serve as imperfect gauges of the ancient level. Yet, high as they are, their summits have not escaped erosion, and even those whose vertical sides rise four hundred, five hundred, perhaps seven hundred feet above the plains at their base, bear distinct evidence of diminished height. The name "butte" is given to these tablelands, or benches, especially when they are of limited extent. The plains around them, too, are strewn with heaps of gravel mingled with chips of water-rolled flints and pebbles, and are cut into channels and deep ravines by the streams which each spring run down from the melting snow of the mountain. On every hand the country resembles an immense excavation, made ages ago by some extinct race of men, and not yet smoothed and worn by time and covered with grass.

Of vegetation there is scarcely any. Along the very edges of the streams grow stunted cottonwood trees and willows. The valleys, if overflowed in the spring, produce sedge, coarse grass and rushes. The bottoms of the hills and narrow valleys, into which the sunlight rarely comes, support a growth of aspen trees, but the plains are in general utterly barren. Not a tree or a bush is anywhere to be seen; nothing is visible but the dull gray level, broken here and there by patches of gravel or clusters of sage-brush and gnease-wood. The foot-hills are thickly covered with forests of pine and quaking-asps, and the great mountains form a broad belt of pines and firs, from which rise their rocky summits, as bare of vegetation as the wide plains at their base.

But their sterility is the least objectionable feature of the plains. The heat and dryness is intense. The moment the first rays of the morning sun are felt, the mercury begins to rise, and long before noon it has gone above 100 degrees. By noon it has touched 122 or 123 degrees. Then the gray alkali dust becomes so hot that you cannot bear your hand upon it, and the air dances before your eyes like the heated gases from a chimney. The glare from the earth is almost blinding. Towards the middle of the afternoon a breeze springs up, and speedily increases to a strong wind, intensely hot and dry, which blows the dust in great clouds over the plains. This continues till the sun goes down and the mercury sinks with it. For an hour or two after sunset, as the air grows cooler and cooler, the mosquitoes come forth and make life miserable. From them there is, indeed, but one refuge, and that is almost as trying to the temper as their stings—the rank smoke of a sage-brush fire. Scarcely a night passes during the hot months but the traveler is forced to pile these pungent boughs on the fire, shut his eyes and lie down in the smoke. Fortunately, however, this visitation if not of long duration. In less than three hours after the sun has disappeared behind the edges of the plains, the thermometer has fallen below 50 and frozen the mosquitoes out. Before midnight it is under 32, and ice forms in the camp-kettles. Many times during our trip the range of the thermometer in the space of 24 hours was through 91 degrees.

The attention of geologists was first attracted to this region by the stories and the relics brought home by the early explorers, who, in the days of the gold fever, when the plateau of southern Wyoming was a highway for countless caravans, went out from the settlements beyond the Mississippi to explore the wilderness and lay out new roads. Few, indeed, among them were tempted by their zeal for discovery to depart far from the green pastures and cool springs of the river-bottoms, or to push their way over alkali plains to the "bad lands." Yet of those who did, scarcely one but could tell of warm springs and steaming pools of water, so hot you could not bear your hand in them; hard by, other pools, in which the mercury fell below forty; of geysers, spouting mud and stones; of trap-dykes running across the country for miles like a huge fence; of eroded valleys, bounded by steep bluffs, whose faces were marked with layers of brown and green and pink sandstone. They were never weary of telling of journeys across great plateaux, where, for weeks, not a tree nor a bush was seen, and where on a sudden the traveler found himself on the edge of a great bluff, while below him, stretching away as far as the eye could reach, lay an endless succession of columns and pyramids, capped with great boulders, and of buttes between which wound deep and narrow cañons, like the crooked lanes of a city. The explorer who was bold enough to clamber down the steep sides of the bluff and take his way along the beds of the narrow streams, climbing over loose boulders and crawling under projecting ledges, rarely failed to come back to his companions loaded down with fossils. Sometimes they were the teeth and scales of fishes, or the plastron of a turtle, or the jaws of a crocodile; sometimes bits of ribs, leg-bones and teeth of monsters that became extinct while a third of our continent was submerged in the sea.

The "bad lands" are famous spots for fossils. The whole territory, in truth, from one end to the other, may be said to be a great cemetery of extinct animal remains. You cannot climb up the sides of a butte, you cannot examine in the most careless way the face of any terrace, but you will find the fragmentary remains of animal life. Every outcrop of shale is full of fossil grass, or leaves, or fish. Scarcely a bed of sandstone but is loaded with bones or fresh-water shells. But nowhere are fossils so abundant as in the " bad lands." These *mauvaise terres*, as they are labelled on the maps, require perhaps a word of description. The character of the rocks, almost exclusively sandstone and shale, clearly indicate that the sand and mud comprising them was deposited by water; that Wyoming, in short, was once the bed of a vast sea; that the sea bottom underwent a gradual elevation; that, the higher portions appearing above the water much sooner than the lower, the sea was cut up into innumerable lakes; and that, the land still continuing to rise, the lakes were in time drained and their beds made dry land. No sooner was this completed than erosion began, and the great deposits of detritus began to be worn away, till finally the country was brought to its present state. To the traveler now journeying over Wyoming, the features of the land are high mountains, broad and level plains, buttes, terraces and table-lands.

The name " butte" has lost much of the meaning of the French word, and is applied to almost every isolated mound, great or small, which rises abruptly from the plain. They cannot be likened to hills, as we understand the word, for that dome-shaped, undulating outline is utterly wanting. They are but the remains, the landmarks, if I may so speak, of the ancient level of the country which the eroding waters have spared, and bear all the sharpness of outline so characteristic of erosion by water. In many of them the sides rise vertically from the plain for 400 or 500 feet, and end at the summit in a broad plane as level as the floor. The sides of others, which have not been capped and protected by layers of sandstone, are weathered and cut into all manner of fantastic shapes, greatly enhanced by the color of the strata, some green, some white, some yellow and some dark brown. One of the finest specimens of a butte in all Wyoming is, I believe, Church butte. In length, it is not over 700 feet, with a width across the base of perhaps 300 feet, and a height of 170 feet, but standing alone in the midst of a wide and level plain is distinctly visible for miles in every direction, and be seen from the railroad. Seen from a distance, it has to the good people of Wyoming some likeness to a church, and they have from this fact so named it. To a "tender-foot," as a man fresh from the East is irreverently named, the likeness seems far-fetched, and is only excusable on the ground that the men of Wyoming do not know what a church is. Outside of what there pass for great cities, Cheyenne, Green River and the like, such a thing as a church is never seen, nor does it seem too much to say that all the churches in the territory might be counted on the fingers of both hands.

However this may be, Church butte has its name, and is a great pile of strangely weathered sandstone. The beds are of varying thickness and toughness. The thick one at the bottom is a pale green, and weathers into peaks and small spires. Over this comes a layer of some fine but thick, of course, brown standstone, and withstanding the effects of weather so well that it overhangs the more easily weathered standstone beneath it, projecting in shelves and ledges till, unable longer to support its own weight, huge slabs break off and form heaps of debris at the base.

Of the terraced or bench-land formation, a most excellent example is that immediately behind Green River City. The beds are there of the cretaceous formation, and entirely of shale. That is to say, they are composed of the mud deposited by the still water of an ancient lake. Precisely how thick this deposit may be below the surface cannot of course be ascertained, but above the level of the plane it rises 1,200 feet, and shows unmistakable evidence of the present top being greatly below the ancient summit. This height, it is needless to say, is not made in one clear rise, but in several benches or terraces. The lowest bench runs close along the bed of Green river, and may, not unjustly, be likened to the Palisades. At the foot of bench lie heaps of crumbled shale, out of which the bluff rises almost perfectly vertically for over 400 feet.

The strata comprising it lie in thick horizontal bands, some of them cream color, some pale yellow, some buff and then shading off to a brick color. Above this, and sloping back at so great an angle as the nature of the crumbled shale will allow, is a second immense pile of debris, out of which rises a second bench, as high but not so regular as the first. In the gaps of this bench fragments of the old broken-down bluff still remain — huge rectangular masses coming out of mounds of broken shale, like tall chimneys or monumental columns. One such mass, known as Chimney rock, stands just behind the Town Hall at Green River City, on the summit of a steep hill, made up of fine-grained earth, which once composed the shale. To a spectator standing on the railroad platform, Chimney rock seems to be not more than 50 feet high. But the measured height of its top above its base is 180 feet—so difficult is it in this region of "magnificent distances" to form a true idea of altitudes.

As might be expected, these Green river beds are rich in fossils. One of the finest fish-deposits in the world is the railroad cutting some three miles out of the city, and I have myself, while riding along the river edge at the foot of the bluffs, pried out here and there with my sheath knife large flakes of shale, and invariably found in them water grasses, leaves, or fragments of a fish.

Impressive as are such scenes of magnificent desolation, they are not to be compared to the scenes in the bad lands which are scattered over the southern portion of the Territory. It fell to the fortune of the members of the Princeton party to pass a month in one of these spots. The expedition started early in June from Fort Bridger, an old fort built in the southwestern corner of Wyoming, to overawe the Mormons in the days when a Mormon differed from an Indian only in color. It came direct to Green River City, turned to the south, and after three days' riding entered the bad lands. This ride, despite the long journeys, often extended from sunrise till long after midnight, in search of water, was quite a pleasant one, as the trail wound along the beds of deep cañons, among beautifully wooded buttes and valleys, and over two mountains whose flat tops were more than 9,000 feet above the sea.

The ascent of the first of these, known as Aspen mountain, was literally through a garden of flowers. The snow was not yet gone, and the earth, soaked with water from the melting drifts, supported a luxurious growth of those delicate flowers, which seem to flourish only at such altitudes. The brilliant colors, blue, yellow and crimson, of the flowers, stood in marked contrast with the long patches and ridges of snow. Far to the south of Aspen mountain rose a second, known as Pine bluffs, and some twenty miles beyond this lay the bad lands. They were entirely below the level of the plain, so that one literally stood on the edge of a precipice before the least trace of the excavations below him became visible. But what was then seen defies description. The eroded area was in three immense basins, each smaller and lower than the other, so that, standing at the edge of the plain and looking downward, the bad lands presented the appearance of an amphitheatre, of which the bed of the lowest basin, stretching away till it disappeared in the distance, was the arena, and the two benches separating the first and second and the second and third basins were the tiers of seats. From the plane to the bottom of the first basin the walls were so steep that only here and there a descent could be made, yet very irregular and broken, sometimes jutting out in long thin masses, again scolloped into deep recesses or broken through by narrow cañons that wound and twisted, crossed, and recrossed, and finally terminating in one cañon which led into a cup-shaped excavation. In such places the sides were almost perfectly vertical, 150 or 160 feet high, and made up of brightly colored beds of sandstone. Usually the lowest bed was pale green, which under the action of the sun weathered pink. Over this was a thick bed of green sandstone, then a lighter green layer, all streaked with dark green clay, the whole capped with a stratum of dark brown. Above this the bands of color were repeated over and over again to the top. On the floor of these walls were to be seen every conceivable form of erosion, pyramids, cones, mounds, and table-like platforms, which here and there stood up, isolated or in clusters of two or three tall needles of sandstone, each capped by a boulder of hard brown sandstone, to whose protection they owed existence. Out from the walls and scattered over the floors of the basins stood small buttes, some with steep vertical sides and broad tops, others with sides broken by benches and ending hundreds of feet above them bases in sharp edge not two feet wide. But, like Melrose Abbey, the bad lands to be seen in all their splendor must be visited " in the pale moonlight." The glittering whiteness of the rocks, the deep black shadows cast by every projecting ledge, the faces of the walls weathered into caves and hollows of the strangest and most fantastic shapes, the huge boulders piled one upon another, or standing out alone in the bright moonlight and casting curiously shaped shadows, all combine to produce an effect unequalled by any of the drawings of Doré.

The chief attraction of the bad lands for the geologist is not, however, the scenery, but the fossils; for there, buried in the rocks, are the remains of multitudes of animals forever extinct. If the explorer search along the bottom of the rain-washes and ravines he will often come upon the fragment of a bone, and will generally find beyond it other fragments, and still others, forming a long line of bone chips, which lead him to some elevated position on the bank, where lies, half buried in the rock, parts of the skeleton of a monster of the ancient world. He may perhaps find a jaw, or an entire skull, or some rib-bones or vertebræ, all of them badly flattened if not broken by the weight of the mass of sandstone above them, thus indicating that they were buried while in a tender state. An entire sketeton, indeed the greater part of a skeleton, is never found, for the bones have almost in every case been buried in the beds of great lakes or seas, and the bones in all probability drifted hither and thither over the bottom by the currents.

Could we, by some magical process, be carried back this evening into Kansas or Wyoming, and placed on the shore of its cretaceous sea, we should feel ourselves in a world completely new to us. The whole features of the land would be changed. Around us on every hand would be plants and animals of a kind now found nowhere out of the tropics, and with them would be others utterly unlike any creature now existing.

Far out on the expanse of waters, for example, would perhaps be seen a snake-like form rising erect with tapering throat and arrow-shaped head, twenty feet above the water. This extraordinary neck, for neck it was, rose from a body of elephantine proportions, and was balanced behind by a tail of the serpent pattern. The limbs were probably two pair of huge paddles. The creature was Elasmosaurus, a carnivorous sea reptile. In the largest and best-known species yet found, 22 feet represents the neck in a total length of 51 feet. It is, of course, impossible to do more than speculate on the habits of the creature; yet it is reasonable to suppose that, like the snake-bird of Florida, Elasmosaurus often swarm far below the surface of the sea, now and then lifting its head above the water to take a breath of air, and then withdrawing it to search for food 40 feet below the surface, without in the slighest altering the position of its body. That the food for which it sought was made up of many kinds of fish, is proved by the teeth and scabs found among its bones in the position of its stomach. That it was a powerful swimmer, fearing neither wind nor waves, is proved by the great distances at which its remains are found from shore.

But a greater than Elasmosaurus swam in the cretaceous sea, and was, indeed, the ruler of the waters. This creature has been named Pythomorpha. The bones collected by Professor Cope* show it to have been a singular mixture of snake and fish. In the largest species the body must have measured 75 feet. The head was large and flat and conic, with a long projecting muzzle, not unlike that of the blunt-nosed sturgeon. The eyes were directed upwards, and the roof of the mouth was like the mouth of a snake, furnished with four rows of double teeth. Such teeth could not, of course, have been of any use in mastication, but were designed simply as weapons for seizing prey. You will recall that the teeth of a snake, instead of pointing vertically upwards and downwards, point backwards in the mouth, and, by the forward and backwack motion of the jaws, act as rakes or clutches, which grip the food and assist in forcing it down the throat. The teeth of Pythomorpha did the same duty, and its habit of swallowing its food entire gave rise to a most peculiar arrangement of the jaw. The snake possesses an extension-jaw, so to speak, which gives wonderful expansibility of throat. The lower jaw is supported by a system of levers, which fold up when the mouth is empty, but are called into play the moment any large body is to be swallowed, shove down the lower jaw, and so greatly increase the capacity of throat. Instead of this, each half of the lower jaw of Pythomorpha was jointed at a point nearly midway between the ear and the chin. The joint was of the ordinary ball-and-socket type, and enabled the jaw to make an angle outward. This arrangement may, to a certain extent, be represented by holding the hands near together. By turning the elbows outward and bending them the space between the arms becomes diamond-shaped and represents exactly the expansion in the jaws of these reptiles to permit the passage of large fish entire.

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* The descriptions of Elasmosaurus and Pythomorpha are taken from the writings of Professor Cope.

From this peculiarity follows a long train of consequences, which may be mentioned as illustrating the mode of reconstructing animals from their bones. The habit of swallowing food entire must have necessitated the prolongation forward of the mouth of the gullet. The throat, therefore, of Pythomorpha must have been as loose and boggy as a pelican's. But the glottis or opening of the windpipe is always in front of the gullet. In Pythomorpha the glottis must, in consequence of the position of the gullet, have been well forward in the mouth, and the creature could have uttered no other sound than a hiss.

Elasmosaurus and Pythomorpha were the largest creatures known to have swam in the cretaceous sea, but those waters were no less remarkable for their fish than for their reptiles. Sharks seem to have been few in number, but the waves swarmed with great predaceous fishes related to the salmon. In the largest specimen yet found, the head is a few inches larger than that of a fully-grown grizzly bear, the muzzle is deeper than that of a bull-dog and the teeth as long as the fangs of a tiger. A few of these in each jaw projected three inches beyond the gums and are sunk in pits an inch deep.

The remains of such fish, plentiful as they are, fall far short of those of a smaller variety, somewhat allied to the herring. Travelers over the Union Pacific Railroad are familiar with them. They are exposed for sale at almost every station from Cheyenne to Salt Lake. But their distribution in nature is by no means so diffuse

They are limited to a few localities, where they occur in great numbers. One such fish-bed is just out of Green River City, and was opened up while making a cutting for the railroad. A second one is at Morgan's meadows, some 25 miles south. These meadows are in a long and very narrow valley, along the bed of which flowed a stream of clear water scarcely a dozen feet wide; for a hundred feet or so on each side of the stream grows tall, rank grass, and where the grass ends the bluffs begin. For a thousand feet along the sides of the valley the underlying beds of shale crop out from the bluffs and rise in benches, one above the other, for a height of 300 feet, presenting such a sight as can be seen nowhere out of that region. The face of each bench is almost vertical, but exceedingly irregular. Huge masses of shale stand out like buttresses or jut out in overhanging slabs and shelves, or hang from the walls like oriel windows, and present a constant succession of richly colored strata—some brown, some buff, some vermillion, orange, gray, pink, salmon color, slate, blue and white. In a brown strata, scarcely 50 feet up the bluff, are the fish. To obtain them, great lumps of the shale are broken off with a pick or crowbar, and the thin layers of the strata scaled off with a knife. On the slabs thus obtained will often be found five to eight fish crowded together within an area of a square foot. Nor is it by any means uncommon to see three fish lying one across the other, in so fine a state of preservation that the color of some of their scales can be detected.

To account for the presence of such multitudes of fish within so small an area, all manner of theories have been advanced. Some have asserted that these places were the favorite spawning grounds of the fish, which, returning each succeeding year, perished in great numbers. Others, again, will have it that the fish-beds mark the mouth of streams or rivers which emptied into the cretaceous sea, and brought down in the waters food of which the fish were fond; that great schools of them congregated at such places, and, as they died, were quickly covered up by the silt of the river. But there are not wanting those who argue from the fact that so many fish are found in the same strata, so close together and so well preserved, to the conclusion that they must all have died at the same time and been almost immediately covered. That they were, in a word, buried up by the fall of an overhanging bank, by a landslide, or killed by an earthquake. Yet a fourth theory supposes the fish-beds to mark the site of estuaries or arms of the sea which were cut off and turned into ponds and lakes, where the fish died from the freshening of the water.

While there is thus much reason to believe that such fish as have come down to our time as fossils met with an untimely end through the violence of nature, there is no reason to doubt that many more suffered from the rapacity of a creature which, like Milton's fiend, was equally at home in the air, in the water, on the land.

This animal was, indeed, a strange mixture of fish, flesh and fowl. When the first skeleton, almost a perfect one, was discovered in Europe, the doctors could not at all agree as to what it was. One held firmly to the opinion that it was a bird; a second firmly maintained that the skeleton was that of a bat, while a third was quite sure the remains could be those of nothing else than a flying reptile. Nor was either opinion groundless. The shape of the head and the length of the neck were very like those of a bird. The wings, in form and proportions, closely resembled the wings of a bat, while the body and tail were not unlike the similar parts of reptiles. As is usual among reptiles, the head was small, but armed with a large beak, containing not less than sixty sharply-pointed teeth. The eyes were of great size, to enable the creature, it is quite probable, to see at night. From the wings projected fingers ending in long hooks, like the curved claws on the thumb of a bat. Besides this, the Pterodactyl (such was the reptile's name) was armed with a paw, enabling it to climb or creep, or hang suspended from the limbs of trees, or stand erect on the ground and walk with wings folded after the manner of birds. In a word, if you can imagine a creature with small body, long neck, small head, large eyes, a beak armed with teeth, and large, leathery bat wings provided with hooked fingers, you will have some idea of the pterodoctyl. In one specimen the spread of the wings was 18 feet, in another 25 feet.

On the land the animals were quite as numerous and remarkable as in the sea. The mere mention of their names would be as tedious as the catalogue of the ships in Homer. Yet a few of them may safely be given, as illustrative of the life of the times. There, for instance, lived the rhinoceros; the procamelus, the forerunner of the camel, and the orohippus, or mountain horse, not much larger than a fox, and believed to have been the ancestor of the horse. There, too, were species closely allied to the cat, the fox, the beaver, the porcupine, the wolf, bats and squirrels, moles and monkeys. But the most numerous of all were crocodiles and turtles. The country, indeed, must have swarmed with them. Their remains, rarely in a well preserved state, are scattered along the bed of every little cañon and ravine in the bad lands, lie bleaching on the top of every beach, protrude from the faces of the butts, and are a veritable nuisance to the searcher after more interesting remains. Many a time have I seen, 40 or 50 feet up the side of an almost perpendicular wall of sandstone, one of the peculiar spots that invariably indicate the presence of bones, have climbed up with the greatest caution on hands and knees, gained a footing on some projecting ledge and stretched up, to find myself confronted by a turtle gone utterly to pieces, or by the remnants of a crocodile jaw, easily recognized by its peculiar pock-marked appearance. Yet the fact that so many fragments of the crocodile are found is not without interest, as, till a few years ago, they were not known to exist anywhere on this continent. Some few years ago four of them were found in a swamp in Florida, and even these are held to be doubtful specimens. Alligators there are in plenty along the Mississippi and in the Gulf States. But the alligator and the crocodile are quite different. Not to enter into minute differences, there is one easily seen and remembered. In the alligator, the upper entirely covers the lower jaw, so that the teeth of the lower jaw fit into sockets in the upper jaw. In the crocodile, the upper jaw contracts just back of the snout, and a whole row of lower teeth come up outside the upper jaw like tusks. Perhaps the distinction will be made more apparent by showing, on the screen, a photograph of the finest crocodile head yet found in the Wyoming bad lands.

In the same beds with these reptiles are the remains of purely land animals of more than elephantine proportions. Such was the Dinoceros discovered by Professor Marsh. The animal was somewhat larger than the elephant and armed with both horns and tusks : one pair of small ones on the snout, a second pair a little further back, and a third and largest pair quite far back on the head. Besides these, there came from the upper jaw a pair of tusks eight inches long. Another monster was the Tlixtatherium ; another the Coryphodon ; another Palæosyops, closely related to the tapir ; another Byrachyos, remotely connected with the rhinoceros ; another the Tillotherium, an animal which combined the head of a bear with the incisors of a rodent, and many of the characteristics of hoofed animals. But a more remarkable still was Oncodon. This was intermediate between the hog, the deer and the camel. The Loxolophodon was intermediate between the elephant and the tapir.

Why the remains of such land animals should be found huddled together with those of marine animals in some localities, and not a bone of them to be found at other places but a few miles away, is not known. The reason can only be guessed at. One theory offered in explanation is, that the spots now so rich in bones were, in tertiary days, great swamps or marshes where the creatures came to wallow, and were mired. Another regards such places as the margins of lakes to which the Loxalophodons, the Coryphodons, the Oncodons, driven from their feeding grounds by droughts, came in herds in search of water, and that when the edge of the lake was reached those in front were driven into the water and trampled on by the rush of the thirsty ones in the rear, and so perished. This is precisely what takes place every few years on the South American Pampas. Still another theory is that the bones are those of animals drowned while attempting to swim a lake or river; that the remains, carried out to sea, were there torn to pieces by the sea carnivores, and that the spots where they are now found mark some quiet eddy into which the currents swept and left them.

This was undoubtedly the case with smaller animal remains. Some fifty miles south of the railroad is a great butte noted on the maps as Twin Buttes. It takes its name from two lofty mounds separated by a narrow cañon. The smaller of the twins is conical in shape, some 600 feet high and eroded into a series of benches, and cannot be better described than a mass of animal remains in a sandstone matrix. There are found the teeth and scales of fish, the vertebræ of snakes, the scutes of lizards, jaws not half an inch long, bones not thicker then a match, and the little brown teeth of Hyopsodus, a species of monkey. The existence of such a conglomeration of remains of land and water animals, all of them so small that the fossil hunter is compelled to creep along the benches on hands and knees to find them, is reasonably explained by the supposition that they were brought there by water. In such spots leaves are never found. They were far too tender to bear transportation by currents. Indeed, wherever leaves are found, the evidence is conclusive that they were deposited in the sediment that accumulated on the beds of fresh water streams or lakes, and they are spread out so smoothly and so entire that no violence, not even that of a rapid current, could have been attendant on their deposition.

While we may thus from the bones reconstruct the animal and from the leaves the plant or tree, so, when the knowledge thus obtained of the plants and animals is joined to our knowledge of the sea margins gained from a study of the rocks, we may with much safety pronounce on the physical features of the land, its climate and its life. From all that we now know, the desert region of Wyoming was once a very pleasant country, a tropical country, rich in herbage and teeming with life. The groves of palms, the sombre forests of poplars, the woods of sassafras and sycamores, the swamps thick with rank grasses and reeds larger than a man's arm; the monstrous crocodiles; the turtles, larger by far than any now existing; the Pterodactyles, spreading out their leathery wings for 25 feet; the sea swarming with reptiles in comparison with which the largest whales sink into contemptible insignificance; the droves of camels and diminutive horses; the monkeys, the tigers, the foxes, the herds of beasts larger than an elephant and more strange than were ever seen in the wildest dream,—make up a land the like of which does not now anywhere exist.

But all this has gone, and the explorer who now enters the "Bad Lands" of Wyoming for the first time can easily fancy that he is the last man. The utter desolation of the place, the dried up watercourses, the absence of every living, moving thing, the profound silence which prevails, produce a feeling quite oppressive; and as he beholds the chips and fragments of bones around him, can scarcely realize that he is looking on all that is left of a great world, which had utterly passed away before the first articulate word was spoken, or the first of human beings looked upon the sun.